Application Note

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Digital Satellite Equipment Control (DiSEqC™) using MC68HC908QT/QY

By Stanislav Arendarik
Motorola Czech System Application Laboratory
Roznov pod Radhostem, Czech Republic

Freescale Semiconductor, Inc.

Introduction

This document describes using the Motorola MC68HC908QT/QY series microcontroller unit (MCU) as the DiSEqC™ (digital satellite equipment control) slave. The in this application note is a twin satellite/LNB switch, but it could easily be adapted to other applications, such as a dual LNB (twin LNB integrated within same horn), or a four satellite/LBN switch (or quad LNB). With appropriate hardware and software enhancements, many other features can be implemented.

The DiSEqC system is divided to two main groups: level 1.x and level 2.x.

- Level 1.x — One-way communication between integrated receiver decoder (IRD) and satellite outdoor unit (ODU).
- Level 2.x — Two-way communication that supports a return-signalling path and multiple peripheral devices.

The DiSEqC system uses the existing coaxial cable as the communication bus that connects satellite receivers and satellite peripheral equipment. DiSEqC control is a standard solution that replaces other analog control systems and wiring.

According to the DiSEqC bus specification, the advantages of DiSEqC are:

- Standardized digital system with non-proprietary commands
- Enables switching in multi-satellite installations
- Backwards compatible with 13/18 volt and 22-kHz tone switching
- Potential for reduced power dissipation and thus cost reduction and improved reliability
- No switching problems caused by incompatibility of system components
- Simplified receiver installation using device recognition via optional two-way communication

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DiSEqC Introduction

The DiSEqC standard is a single master, single or multiple slave system, so communications may be initiated only by the master tuner-receiver/IRD. The The slave devices can be switches, LNBs (low noise blocks), positioners, or other special devices used to establish satellite program reception.

The bus transfers:

- dc power supply — usually 13-V/18-V; max 500 mA
- RF signal — IF band from 950 MHz to 2150 MHz
- 22-kHz tone signal — nominal 650 mV (± 250 mV) peak-to-peak
- DiSEqC data modulated on the 22-kHz tone signal (if used)

To help ensure the transport of the 22-kHz signal, the total load capacitance of the entire bus (cable) should not exceed 250 nF. At this load, the bus can tolerate a cable as long as 50 meters. DiSEqC peripherals should not load the bus by typically more than 100 nF. For certain classes of devices such as SMATV (satellite master antenna television) nodes and installer aids, a much lower value is preferred.

DiSEqC Signal/Protocol

See the DiSEqC bus specification from http://www.eutelsat.com for complete bus specification.

There are several signal possibilities on the bus:

- Earlier non-DiSEqC units (one-band LNBs)
  - dc current of 13-V/18-V (for switching horizontal/vertical (H/V) polarization)
- Earlier non-DiSEqC units (two-band LNBs)
  - dc current of 13-V/18-V (for switching between H/V polarizations)
  - Continuous 22-kHz tone signal for low or high band selection
- Non-DiSEqC messages
  - dc current of 13-V/18-V (for switching between H/V polarizations)
  - Continuous 22-kHz tone signal for low or high band selection
  - Tone burst signalling to switch between A and B positions of two-band LNBs
- Any combination of these signals and DiSEqC messages

It is possible to have DiSEqC and non-DiSEqC signalling on the bus. Having both types of signals on the bus allows the user to control accessories of both types and does not require the user to configure the master tuner-receiver/IRD to a particular command protocol. This is possible because the control data of both protocols should be the same, and a DiSEqC slave (MC68HC908QT/QY) will recognize and perform control signals from both command protocols.

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Application Characteristics

This application using the MC68HC908QT4 as the DiSEqC slave has the following characteristics:

- Two LNBs will be controlled (default is satellite A).
- Because the MC68HC908QT/QY series is compatible with non-DiSEqC control, it is possible to use the earlier satellite receivers with voltage (13 V to 18 V), tone (22 kHz present or not), and tone-burst control capabilities.
- The switch (MC68HC908QT4 plus additional components) automatically detects whether the tone-burst protocol or DiSEqC is used. After power-up or reset, the ODU can recognize tone-burst or DiSEqC control; after DiSEqC control is received, tone-burst control is blocked.
- DiSEqC level 1.0 will be used.
- The following bus commands are recognized by the DiSEqC slave:
  - Framing byte:

    $E0, $E1
  - Address byte:

    $00 — Any device (master to all devices)

    $10 — Any LNB, switcher or SMATV
  - Command byte:

    $00 — Reset DiSEqC microcontroller (MC68HC908QT/QY)

    $02 — Switch peripheral power supply OFF

    $03 — Switch peripheral power supply ON

    $22 — Select satellite position A

    $23 — Select switch option A (e.g., position A/B)

    $26 — Select satellite position B

    $27 — Select switch option B (e.g., position C/D)

    $38 — Write to port group 0
  - Port group 0 data (first data byte):

    $F8, ($FA, $FC, $FE) — Switch to satellite A

    $F0, ($F2, $F4, $F6) — Switch to satellite B

Because this application uses level 1.0, basic DiSEqC bus commands and the low pin count MC68HC908QT4 are used. Other commands may be added for possible new functions. The MC68HC908QT4 can control a maximum of four LNB for DiSEqC level 1.0 commands. In this case, only two outputs are used, and two are left free. It is possible to implement this software for MCU MC68HC908QY4 to obtain a higher pin count and more control capability to satisfy the DiSEqC level 1.1 or level 1.2 requirements.

The MCU uses the FLASH programmed value for the TRIM register. This value ensures good accuracy of the bus frequency.

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Figure 1 shows the signal block diagram. There are two universal LNBs used, receiving signals from satellite A and B respectively. The ODU (MC68HC908QT4 and some other components) receives the command data signal from the IDU. The commands are sent in the DiSEqC data format (modulated 22 kHz) through the high frequency coaxial cable.

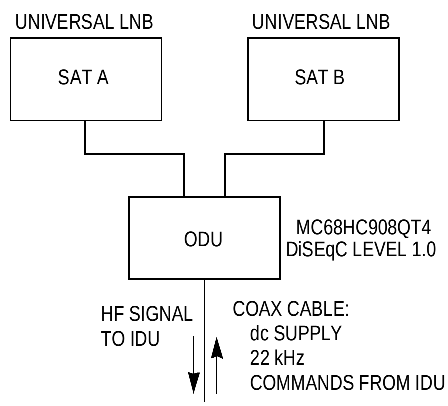

Figure 1. Signal Block Diagram

Figure 2 shows the functional block diagram. The satellite receiver is connected by the coaxial cable to the pin called “IF-Out” (4).

This cable carries:

- Supply voltage +13 V or +18 V at 0.5 A max from the satellite receiver to the LNB switch and the target LNB (LNB-A or LNB-B)
- DiSEqC or non-DiSEqC commands from the satellite receiver to the LNB switch and the target LNB
- High-frequency television signal in the IF band (950 MHz to 2150 MHz) from that LNB through the LNB switch to the satellite receiver

The universal LNBs are controlled by:

- Supply voltages
  - +13 V — vertical polarization
  - +18 V — horizontal polarization
- 22-kHz signal superimposed on those voltages
  - 22-kHz signal is present — high band (11.7 GHz to 12.75 GHz) is received
  - 22-kHz signal is not present — low band (10.7 GHz to 11.7 GHz) is received

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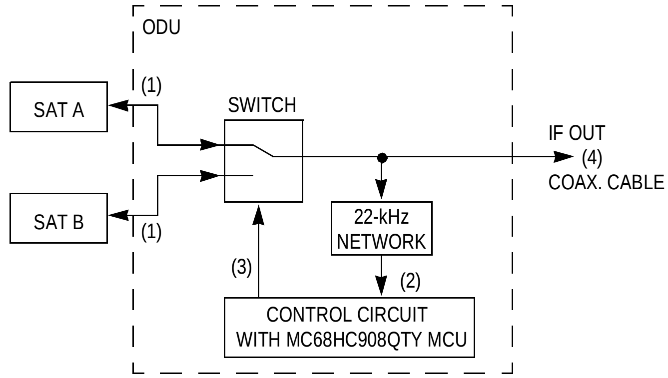

NOTES:
1. I/O FROM SATELLITE LNB (IF 950 MHz TO 2150 MHz, dc SUPPLY, 22 kHz SIGNAL)
2. MODULATED DiSEqC DATA
3. CONTROL SIGNALS FROM MCU
4. COAX. CABLE BETWEEN ODU AND RECEIVER
(dc SUPPLY 20 V, DiSEqC DATA, IF BAND TO RECEIVER)

Figure 2. Functional Block Diagram

The MC68HC908QT4 MCU receives the DiSEqC control message, decodes it, and controls the RF PIN-diode switch.

The DiSEqC switch unit (DSU) controlled by the MC68HC908QT4 MCU allows both DiSEqC and non-DiSEqC control signals from the satellite receiver to be used.

The satellite receiver sends the control message to the LNB switch in accordance to DiSEqC standard level 1.0 (see **References**). The LNB switch switches between LNB-A or LNB-B. The supply voltages and the 22-kHz signal are produced by the IDU (satellite receiver). The capabilities of this control unit with the MC68HC908QT4 can be expanded to a maximum of four LNBs (LNB-A, -B, -C, and -D) in accordance with DiSEqC level 1.0 control standard.

DiSEqC Slave Modes

The DSU (DiSEqC switch unit) works in two main modes, based on the type of control:

– Non DiSEqC control — voltage/frequency/burst control (VFC)
– DiSEqC control

Non-DiSEqC Control (VFC Mode)

In VFC mode, the DSU is not sensitive to voltage changes (+13 V or +18 V) or the presence of the 22-kHz signal.

The signal (voltage and 22-kHz tone) is generated by the satellite receiver to switch the target LNB between H/V polarizations, and between the low and high bands received (22 kHz absent/present). The DSU is through-hold for this signal.

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The DSU in VFC mode is sensitive to tone burst signaling. This control signal enables switching between LNB-A and LNB-B, respectively. This is described in the DiSEqC bus specification from Eutelsat (see **References**).

DiSEqC Control

If the DSU receives a DiSEqC message from the IDU, it decodes it and switches between satellite A or satellite B inputs according to the received control command.

Table 1 summarizes all states that can be used within this small DSU. It's possible to receive all programs from two different satellites in the horizontal and vertical polarization, both in the low and high bands. The detailed description of the message format is in the DiSEqC bus specification from Eutelsat (see **References**).

Table 1. States of DiSEqC Slave Unit

State	LNB A/B	Polar H/V	Band L/H	Msg 1
1	A	V	L	$E0 $10 $22 ($23, $03, $00) or $E0 $10 $38 $F8
2	A	V	H	
3	A	H	L	
4	A	H	H	
5	B	V	L	$E0 $10 $26 or $E0 $10 $27 or $E0 $10 $38 $F4
6	B	V	H	
7	B	H	L	
8	B	H	H	

DiSEqC Slave Unit Description

The schematic is shown in **Figure 3**.

The MC68HC908QT4 MCU is powered by the supply net, which comprises L3, C6, R6, D4, C4, and C5. The supply voltage ranges from 4.5 Vdc to 5.0 Vdc, depending on the kind of zener-diode.

The MCU receives control messages through pin 5 ($\overline{IRQ}$). The 22-kHz net comprises L3, C6, R6, C7, R8, and the Q3 circuit.

The outputs from the MCU are pins 2 and 3. These outputs control the two dc switches according to the control messages received. The first dc switch comprises Q1, Q2, D1, D2, and associated components. The second dc switch comprises Q4, Q5, D3, D6, and associated components. The desired LNB is powered from the IDU through the Q1 (Q5 opposite channel) and low-pass filter L1, C1, and L2 (L5, C8, and L4 opposite channel). The IDU (satellite receiver) produces the desired power supply, +13 V or +18 V respectively, and superimposes the 22-kHz signal if needed.

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The high-frequency circuit comprises D1, D2, and C3 (D6, D3, and C3 opposite channel). Resistor R5 is used to switch the desired PIN-diode pair when the supply voltage is present on the same LNB port. The opposite PIN-diode pair is switched off by the reverse voltage. It is very important to design the correct shape of the high-frequency circuit to match the impedance of the LNB to the coaxial cable (both are 75 Ω).

The output pin 4 (PTA3) is used to send a message back to the IDU by two-way communication (in levels higher than level 1.0). It's possible to use a simple circuit (transistor Q6 with associated components) to produce a pseudo square-wave 22-kHz signal. This signal doesn't comprise the high-frequency disruptive components because of the value of the resistor R7 and the relatively high capacitance of the coaxial cable line (about 50 nF to 100 nF). The two-way communication option is not used in this design example.

The complete DiSEqC slave unit is packaged in a metal case with three F-terminals, which is standard in satellite devices. The PCB is double-sided with a bottom ground plane. The top side of the PCB is shown in **Figure 4**, and the complete encased DiSEqC slave unit in **Figure 5**.

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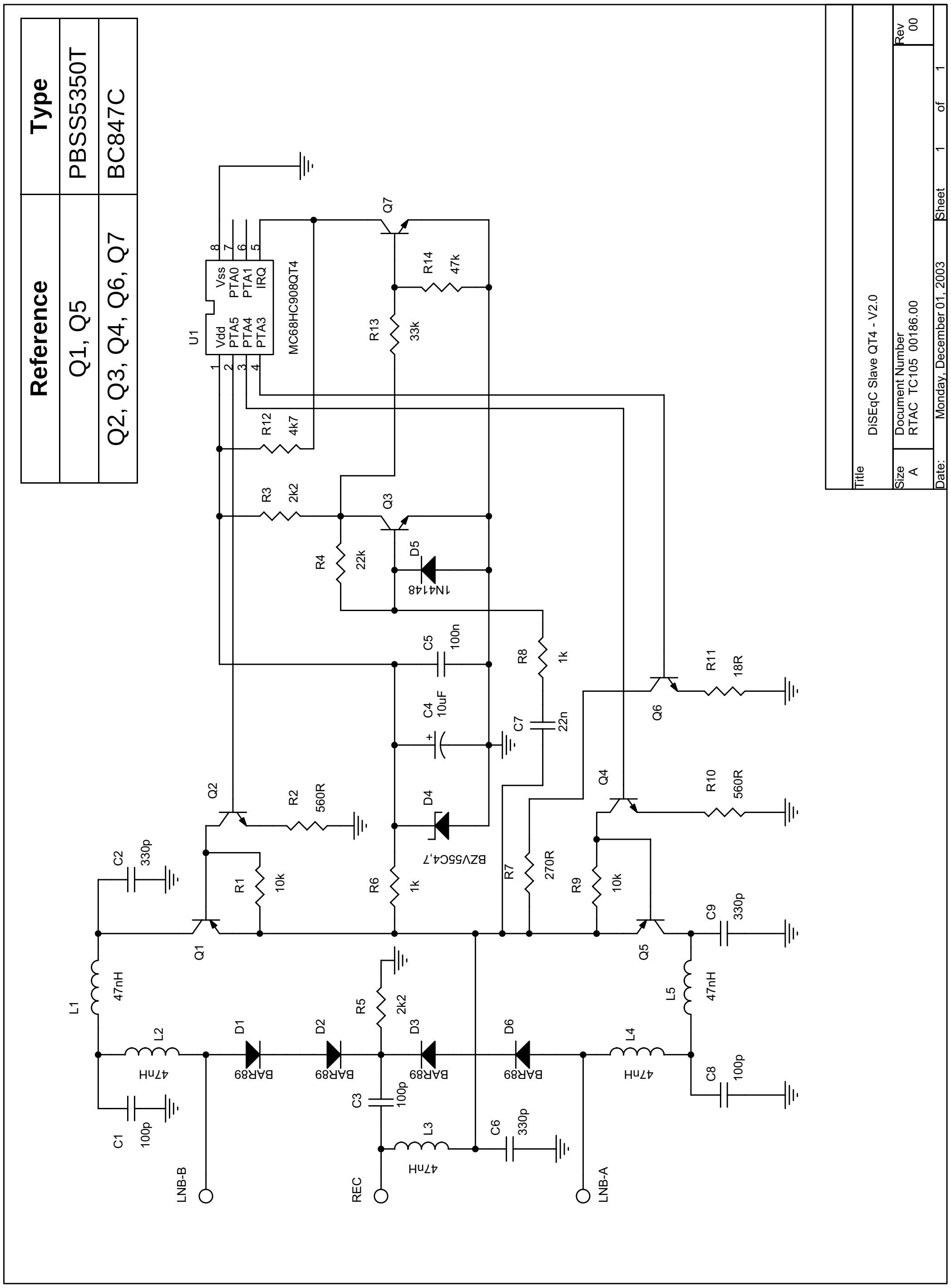

Reference	Type
Q1, Q5	PBSS5350T
Q2, Q3, Q4, Q6, Q7	BC847C

Figure 3. DiSEqC Slave Schematic

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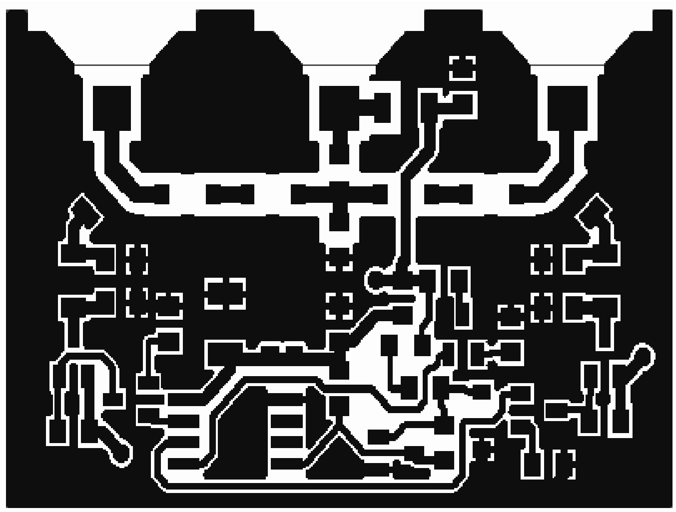

Figure 4. DiSEqC Slave PCB

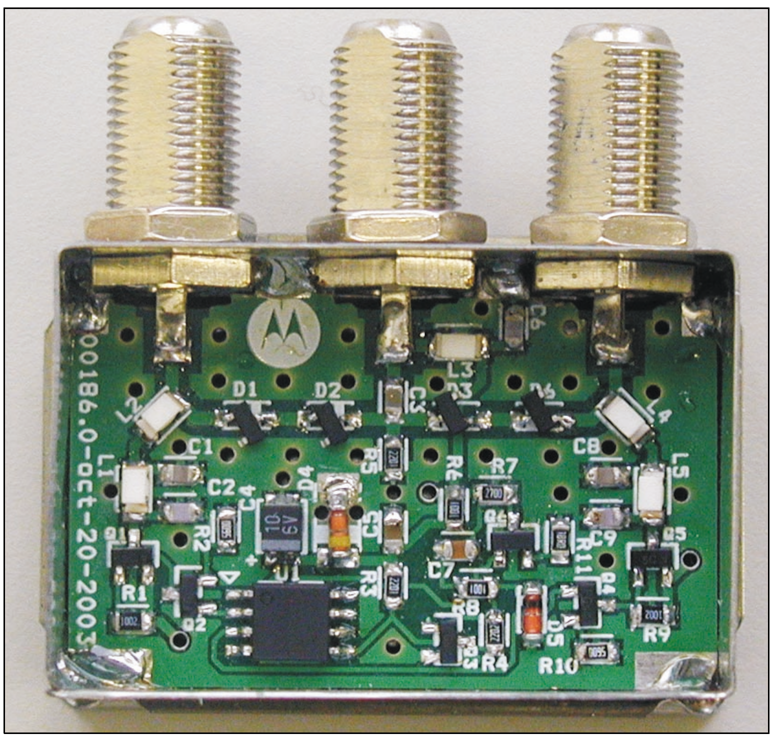

Figure 5. DiSEqC Slave Unit — Ready to Use (46 x 30 mm)

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Software Operation

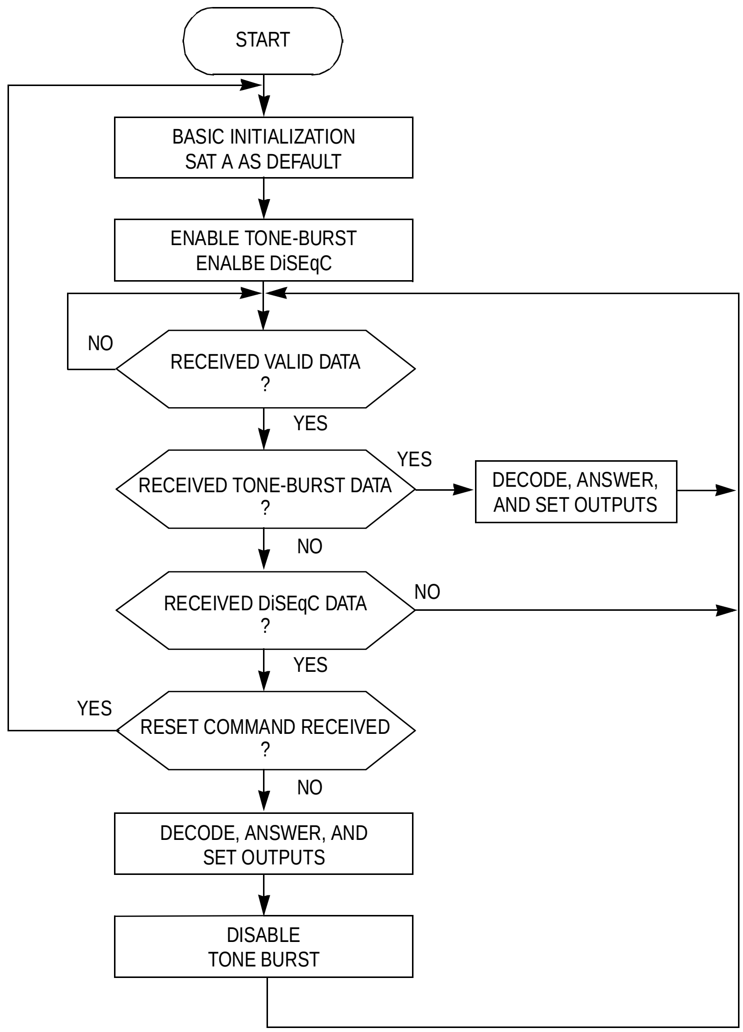

Figure 6. Software Operation

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Conclusion

This application note explains the DiSEqC-control of low noise blocks in a satellite receiver system and demonstrates the basic possibilities of a DiSEqC slave unit. To achieve the basic properties of DiSEqC level 1.0, a member of the low-cost and powerful small (8-pin) universal MCU MC68HC908QT4 series can be used. In this case, pins 6 and 7 are available to be used in the function control ports for the next two LNBs. To satisfy the demands of DiSEqC level 1.x and 2.x, it's possible to use a similar MCU from the higher pin count MC68HC908QY4 series.

References

AN2677SW.zip — from Motorola (http://motorola.com/semiconductors); contains all software files and schematic for this application.

DiSEqC Bus Functional Specification V4.2 — from Eutelsat (http://www.eutelsat.com)

MC68HC908QY4/D: *MC68HC908QT4 Data Sheet* — from Motorola (http://motorola.com/semiconductors)

NOTE: *With the exception of mask set errata documents, if any other Motorola document contains information that conflicts with the information in the device data sheet, the data sheet should be considered to have the most current and correct data.*

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USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
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